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(54) APPARATUS AND METHOD FOR DETECTING AN OPTIMAL WRITING POWER

(75) Inventor: **Jeong Yeol Lee**, Kyunggi-do (KR)

Correspondence Address:
BIRCH STEWART KOLASCH & BIRCH
PO BOX 747
FALLS CHURCH, VA 22040-0747 (US)

(73) Assignee: **LG Electronics Inc.**

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(57) ABSTRACT

A method and apparatus for accomplishing an OPC (optimal power calibration) at a test area secured in data recording area of a writable optical recording medium and detecting an optimal writing power appropriate to the test area. The method searches for a marginal area adjacent to a data section recorded on an optical recording medium, records test data on the marginal area discovered in the searching step while changing a writing power; and reproduces the test data recorded on the marginal area and determining an optimal writing power based upon the characteristics of the reproduction signal. The method and system can reduce delay time required to move an optical pickup inward and outward to accomplish the OPC operation and enhances writing characteristics since an optimal writing power is obtained from a test area which is very close to data area to record input data.

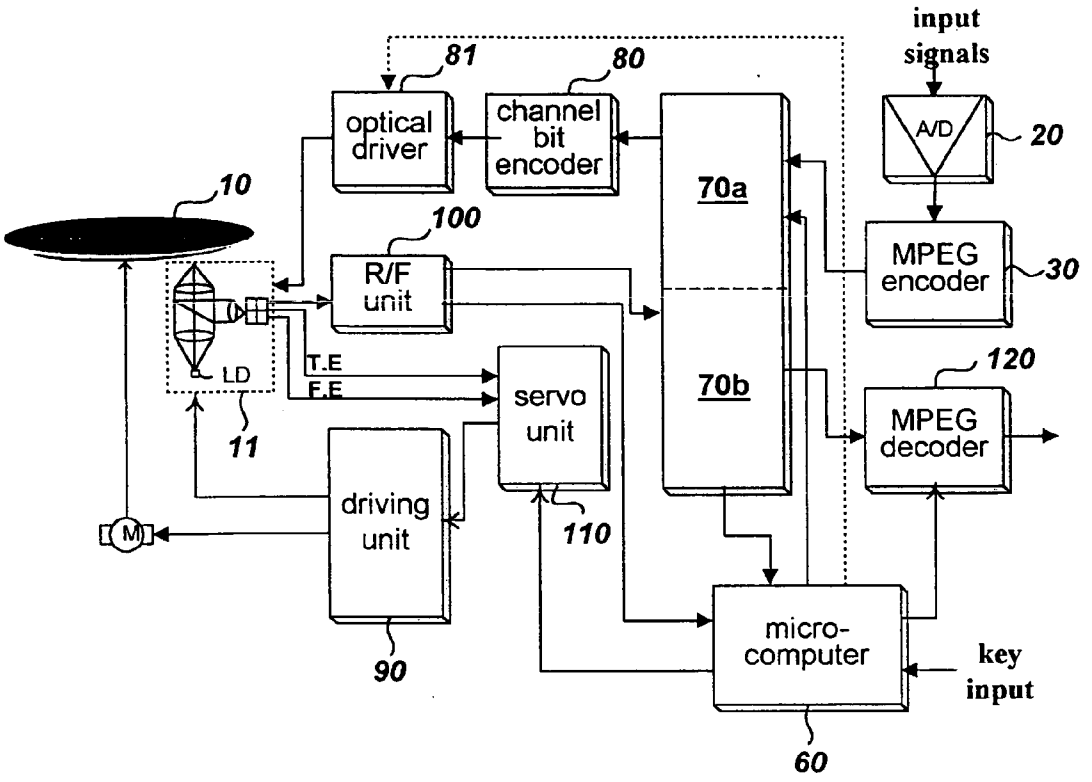


FIG. 1

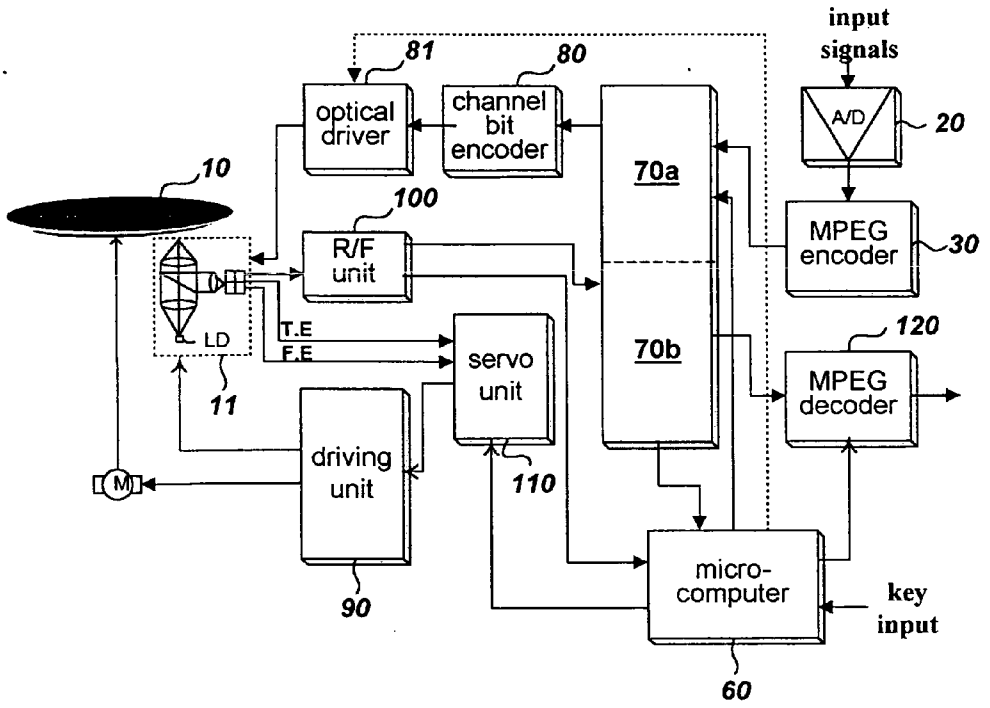
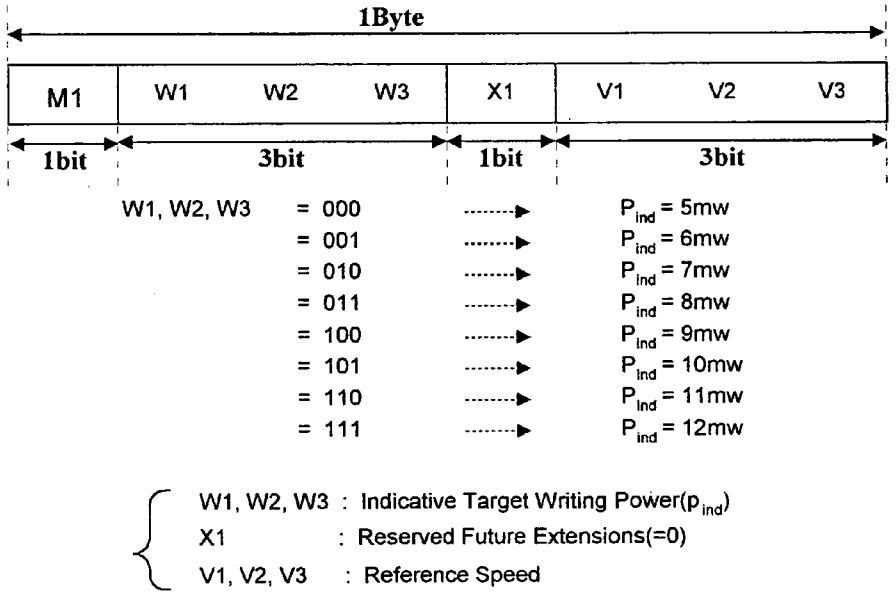
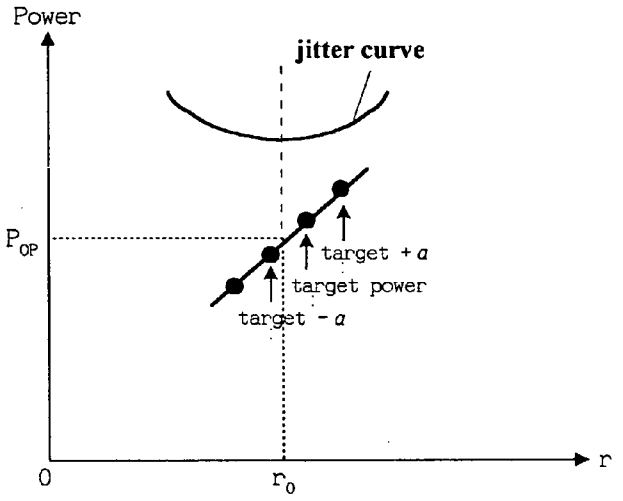


FIG. 2



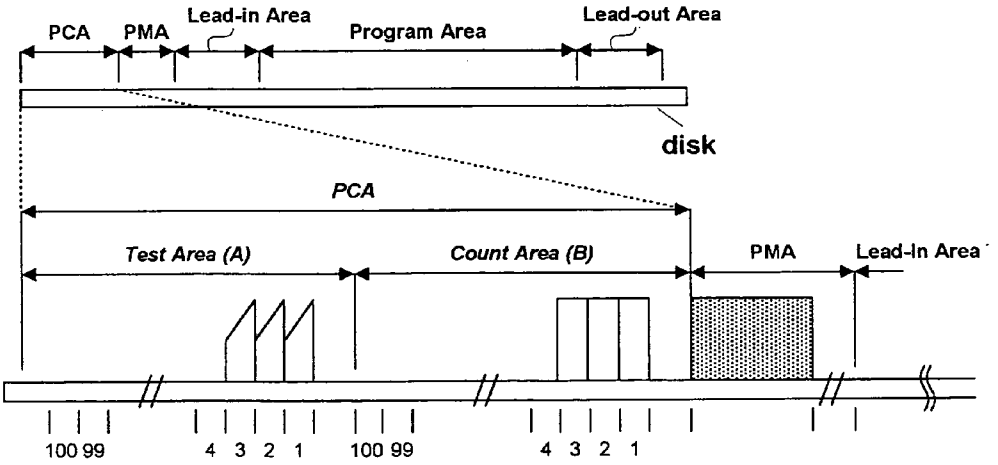
Conventional Art

FIG. 3



Conventional Art

FIG. 4



Conventional Art

FIG. 5

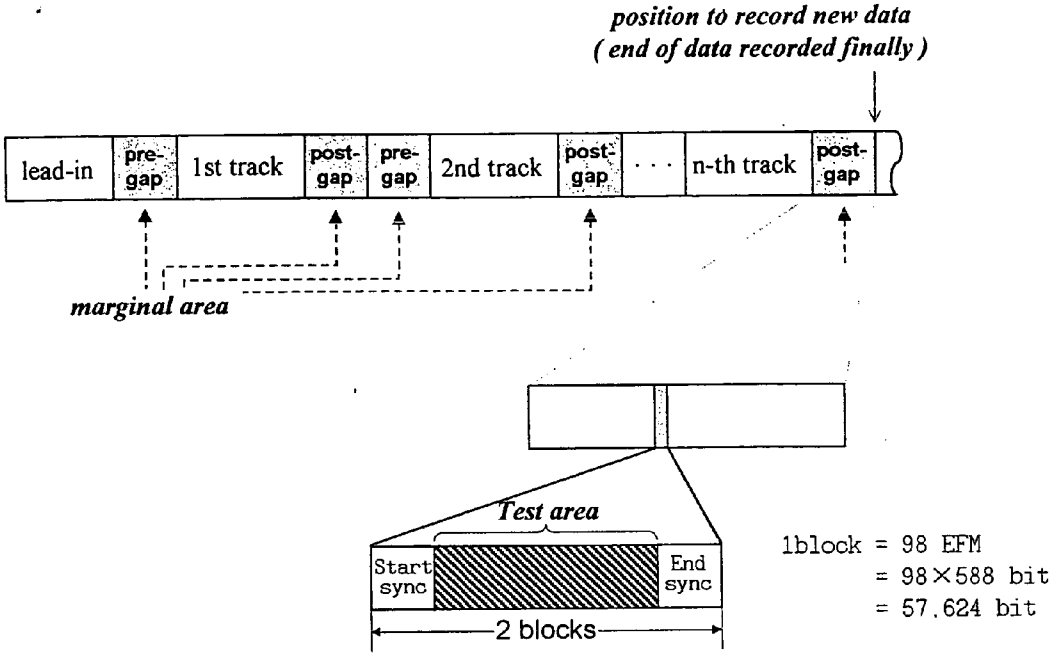

position to record new data
(end of data recorded finally)
lead-in
pre-gap
1st track
post-gap
pre-gap
2nd track
post-gap
· · ·
n-th track
post-gap
marginal area
Test area
Start sync
End sync
2 blocks
1block = 98 EFM
= 98×588 bit
= 57,624 bit

FIG. 6

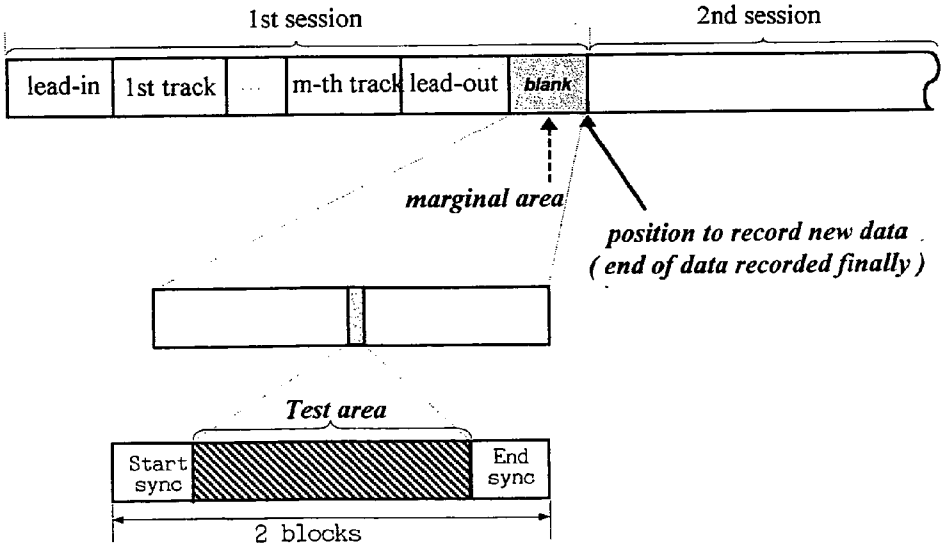
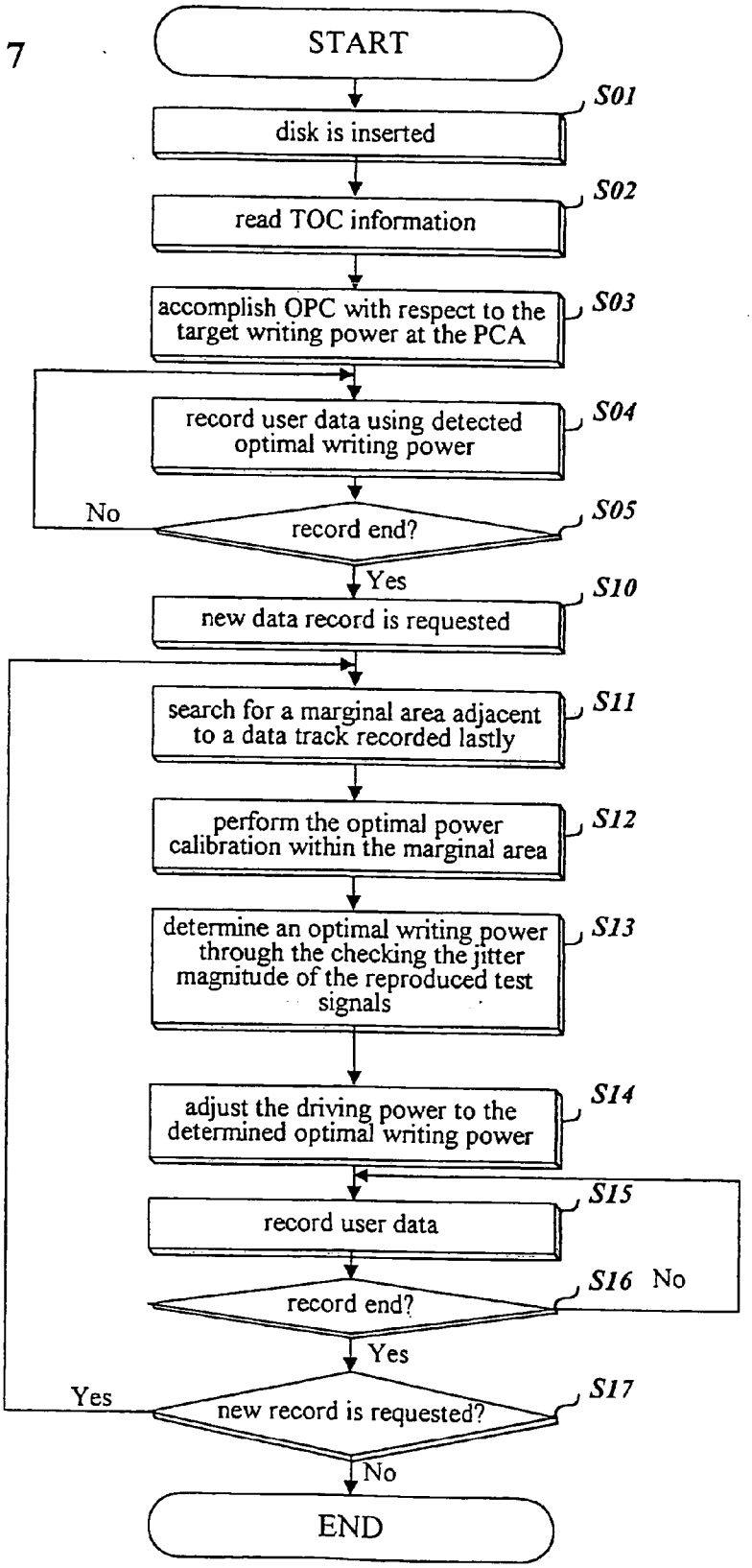

1st session
2nd session
lead-in
1st track
· · ·
m-th track
lead-out
blank
marginal area
position to record new data
(end of data recorded finally)
Test area
Start sync
End sync
2 blocks

FIG. 7


START
S01
disk is inserted
S02
read TOC information
S03
accomplish OPC with respect to the target writing power at the PCA
S04
record user data using detected optimal writing power
S05
record end?
No
Yes
S10
new data record is requested
S11
search for a marginal area adjacent to a data track recorded lastly
S12
perform the optimal power calibration within the marginal area
S13
determine an optimal writing power through the checking the jitter magnitude of the reproduced test signals
S14
adjust the driving power to the determined optimal writing power
S15
record user data
S16
record end?
No
Yes
S17
new record is requested?
Yes
No
END

APPARATUS AND METHOD FOR DETECTING AN OPTIMAL WRITING POWER

[0001] This application is a Continuation of co-pending application Ser. No. 09/549,045, filed on Apr. 13, 2000, and for which priority is claimed under 35 U.S.C §120; and this application claims priority of Application No. 99-12903 filed in Korea on Apr. 13, 1999, under 35 U.S.C. §119; the entire contents of all are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a method and an apparatus for detecting an optimal writing power for recording user data on a writable optical recording medium.

[0004] 2. Description of the Related Art

[0005] **FIG. 1** is a simplified block diagram of a conventional apparatus for recording data on a writable optical disk. The apparatus comprises an A/D converter **20** for digitizing an analog signal, an MPEG encoder **30** for encoding the digitized data into the MPEG format, a digital recording signal processing unit **70***a* for converting the MPEG-formatted data into recording-formatted EFM (Eight to Fifteen Modulation) data while adding additional data such as error correction codes, a channel bit encoder **80** for converting the recording-formatted data into writing signals, an optical driver **81** for yielding signals to drive a LD (laser diode), an optical pickup **11** for recording signals onto surface of a writable optical disk **10** and reproducing recorded signals from the optical disk **10**, a driving unit **90** for driving the optical pickup **11** and a motor M to move and rotate respectively, an R/F unit **100** for equalizing and shaping the signals reproduced by the pickup **11** to produce binary signals, a servo unit **110** for controlling the driving unit **90** based upon a tracking and a focusing error signal provided by the pickup **11** and the rotation speed of the optical disk **10**, a digital reproduced signal processing unit **70***b* for restoring compressed data from the binary signals using a self clock synchronized with the binary signals in phase, an MPEG decoder **120** for restoring original video and/or audio data by decoding the compressed data, and a microcomputer **60** for controlling overall operation of recording and reproduction.

[0006] Upon receiving a request for recording user data, the microcomputer **60** controls the pickup **11** through the servo unit **110** and the driving unit **90** to read the indicative target writing power recorded on the writable disk medium **10**. In case where the disk **10** is a rewritable recording medium such as a CD-RW, the target writing power is recorded as 3-bit data **W1**,**W2**, and **W3** in the **M1** information byte in the field of ATIP (Absolute Time In Pre-Groove) located in the lead-in area of the optical disk **10**. **FIG. 2** shows the recording format of the bits '**W1W2W3**' and the meaning of each value.

[0007] After reading the target writing power data **W1**,**W2**, and **W3**, that is, the indicative target writing power P_{ind}, recorded as above, the microcomputer **60** transfers predetermined test data, for example, a byte of 10101010, to the channel bit encoder **80** through the digital recording signal processing unit **70***a*. For recording digital bit streams outputted from the digital recording signal processing unit **70***a*, the channel bit encoder **80** converts the bit streams into PWM (pulse-width-modulated) signals and applies the modulated signals to the optical driver **81**.

[0008] The microcomputer **60** applies power adjusting data to the optical driver **81** and changes its value in sequence as shown in **FIG. 3** for changing the writing power within a given range with respect to the read target writing power whose intensity is assumed to 8 mW in **FIG. 3**. In response to the power adjusting data, the optical driver **81** outputs writing signals whose power corresponds to the applied power adjusting data so that the pickup **11** records the digital bit streams for testing in the test area of the optical recording medium **10**. In the case where the optical recording medium **10** is a rewritable CD such as a CD-RW, the test data are recorded in test area A of the PCA (Power Calibration Area) as shown in **FIG. 4**.

[0009] Along with recording the digital bit streams for power testing, the microcomputer **60** controls the optical pickup **11** to write null data of one ATIP in the count area B located in the PCA to indicate how many times test writing is accomplished. For example, if this recording of the digital bit stream for power testing is executed thirdly for the disk **10**, the null data are written to the third ATIP of the count area B located in the PCA as shown in **FIG. 4** to indicate that test operations were executed three times.

[0010] On the condition that the test data have been recorded in the test area A of the PCA with the varying writing power, the microcomputer **60** controls the pickup **11** to reproduce the most recently recorded digital bit streams for power testing. While reproducing the test data, the microcomputer **60** keeps detecting the jitter magnitude of the binary signals converted from the reproduced RF (Radio Frequency) signals by the R/F unit **100**. Then, if the detected jitter magnitude is lowest, the microcomputer **60** determines the writing power used to record the test data whose jitter magnitude is lowest as an optimal writing power for the disk **10**. That is, the power Pop is chosen to optimal in **FIG. 3**.

[0011] If external video and/or audio signals are received for recording after the optimal writing power Pop is determined, the received video and/or audio signals are digitized by the A/D converter **20** and encoded into the MPEG formatted data by the MPEG encoder **30**. The digital recording signal processing unit **70***a* generates digital bit streams modulated from the encoded data and error correction codes added to the encoded data by itself. The channel bit encoder **80** converts the digital bit streams into PWM signals and applies the modulated signals to the optical driver **81** to record the modulated bit streams to the disk **10**.

[0012] Meanwhile, the microcomputer **60** sets the optical driver **81** to generate a driving current corresponding to the optimal writing power Pop obtained through the previous procedure. Therefore, the PWM signals whose power is optimal for the disk **10** causes the received data to be recorded in the program area of the optical disk **10**.

[0013] In the above-explained conventional method for recording data on an optical disk, when a request is received for recording new data successively from the record-ending point of the program area after a previous data recording operation is done, the microcomputer **60** performs the aforementioned OPC (Optimal Power Calibration) again. In other words, the microcomputer **60** repeats the OPC whenever a request for recording additional data is received.

[0014] However, the OPC needs to move a pickup inwardly and outwardly, that is, between PCA and program area. This takes a relatively long time to start data recording, and delays the data recording operation.

[0015] Moreover, since the test area A of PCA for an optimal writing power calibration is located inwardly from a lead-in area of the program area of an optical disk where user data are to be recorded, the characteristics of recording environment of the program area may be different from that of the test area. Accordingly, sometimes an optimal writing power detected from the test area is not optimal for the recording area where user data are to be written.

SUMMARY OF THE INVENTION

[0016] It is an object of the present invention to provide a method and an apparatus for detecting an optimal writing power, which reserves OPC areas in the user data area and detecting an optimal writing power through test writing and reading at the reserved OPC areas.

[0017] The optimal writing power detecting apparatus according to the present invention comprises a writing/reading means for recording and reproducing data to/from the recording medium; a servo controlling means for moving said writing/reading means to a reserved spare area adjacent to a data section recorded in the recording medium; and a controlling means for controlling said writing/reading means to record test data in the reserved spare area while changing a writing power and to reproduce the recorded test data from the spare area, and detecting an optimal writing power based upon the characteristics of the reproduced signals.

[0018] The optimal writing power detecting method according to this invention comprises the steps of searching for a marginal area adjacent to a data section recorded on an optical recording medium; recording test data on the marginal area discovered in the searching step while changing a writing power; and reproducing the test data recorded on the marginal area and determining an optimal writing power based upon the characteristics of the reproduced signal.

[0019] In the present invention, the servo controlling means moves the writing/reading means to the reserved area adjacent to the data section on which user data have been most recently recorded on the optical disk, and the writing/reading means writes test data in the reserved area. While the data are being written, the controlling means controls the writing power of the writing/reading means to be changed step by step. After such writing of the test data, the test data are then reproduced by the writing/reading means and an optimal writing power is determined based upon the quality of the reproduced signals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiments of the invention, and together with the description, serve to explain the principles of the present invention.

[0021] In the drawings:

[0022] **FIG. 1** is a simplified block diagram of a conventional data recording/reproducing apparatus;

[0023] **FIG. 2** is a data example corresponding to the indicative target writing powers recorded on a rewritable optical recording medium;

[0024] **FIG. 3** is an illustrative graph showing the writing power being changed within a range with respect to the designated target writing power when recording test data;

[0025] **FIG. 4** is a view of the test area reserved in the PCA of a CD-RW for detecting an optimal writing power;

[0026] **FIG. 5** is a data recorded example for a writable optical recording medium reserving test areas between data tracks of the present invention;

[0027] **FIG. 6** is another data recorded example of a writable optical recording medium reserving test areas between data sessions of the present invention; and

[0028] **FIG. 7** is a flow diagram of an optimal writing power detecting method for an optical recording medium according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0029] In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

[0030] The apparatus embodying the present invention is all the same as that shown in **FIG. 1** except that the microcomputer **60** according to the present invention regards the part of marginal areas such as pre-gap areas, post-gap areas, and blank areas as test areas for OPC, and searches for OPC areas based upon sync data preceding and following each test area when data recording is requested.

[0031] The pre-gap and post-gap areas are reserved for every data recording track, and the blank area is reserved for every a data session in a writable optical disk.

[0032] The writable optical disk according to the present invention reserves the marginal areas located adjacent to data recording sections such as tracks or sessions as well as a conventional OPC area located inner than a lead-in area as OPC areas to be used for detecting optimal writing power. The marginal area consists of sync areas for a start sync and an end sync data, a test area reserved between the sync data, and a spare area. The test area is allocated 1~2 blocks in size with the sync areas included.

[0033] The codes of a start sync data and an end sync data may be different each other, for example, if **16** bits are allocated for each sync data, $\mathbf{0F0F}_{(16)}$ is for the start sync code and $\mathbf{0E0E}_{(16)}$ is for the end sync.

[0034] The data section means one track if data are recorded and grouped in a track unit, and it means one session if data are recorded and grouped in a session unit.

[0035] The marginal area shall be a pre-gap and a post-gap, whose size may be more than 150 blocks, before and behind a data track if data recorded are grouped in a track unit as shown in **FIG. 5**, and it shall be a blank area, whose size may be also more than 150 blocks, following a data session if data recorded are grouped in a session unit as shown in **FIG. 6**.

[0036] **FIG. 7** is a flow diagram of the optimal writing power detecting method embodying the present invention.

Referring to **FIG. 1** assumed to have the microcomputer **60** replaced with one according to the present invention, the operation of the apparatus and the optimal writing power detecting method in accordance with the present invention will be explained in detail.

[**0037**] When the writable optical disk **10** having no recorded data is inserted (**S01**), the microcomputer **60** moves the optical pickup **11** to the lead-in area of the optical disk **10** through controlling the servo unit **110** and the driving unit **90** to retrieve various recording/reproduction control information recorded in the lead-in area, and temporarily stores the retrieved information in an internal memory (**S02**).

[**0038**] The microcomputer **60** also performs the conventional optimal power calibration (**S03**) which records test data in the PCA area of the optical disk **10** while changing a target writing power step by step, then reproduces the recorded data while detecting an optimal writing power based upon jitter characteristics of the reproduced signals.

[**0039**] After the optimal writing power is detected, the microcomputer **60** determines the recording format of the disk **10**. If the recording format is track unit, the microcomputer **60** controls the optical pickup **11** to skip non-recorded area through the servo unit **110** and the driving unit **90** to secure a pre-gap of more than **150** blocks. Skipping the pre-gap area, the microcomputer **60** records the inputted user data on one or more data tracks having both of a pre-gap and a post-gap (**S04**), and when the recording is done (**S05**), the microcomputer **60** also secures a post-gap behind the last recorded track.

[**0040**] Meanwhile, whenever a pre-gap or a post-gap is secured, the microcomputer **60** writes sync data in front of and to the rear of a selected test zone to specify the test zone inside of the secured area.

[**0041**] When a new recording of user data is requested (**S10**) after the previous user data recording is finished according to above operation, the microcomputer **60** does not move the optical pickup **11** to the PCA area at this time. Instead, the microcomputer **60** controls the servo unit **110** and the driving unit **90** to move the optical pickup **11** to one of both reserved areas of a pre-gap and a post-gap preceding and following the last track on which user data were recorded. Preferably, the microcomputer **60** moves the pickup **11** to the post-gap rather than to the pre-gap, since the post-gap is nearer to a track for in which the new data are to be recorded (**S11**).

[**0042**] Then, the microcomputer performs the optimal power calibration within the reserved test area in the post-gap (**S12**) through writing and reading of the optical pick **11**. Before this writing process, the microcomputer **60** searches for the start sync data recorded before the reserved test area. When the start sync data are found, the microcomputer **60** records test data in the test area. At that time, the microcomputer **60** controls the optical driver **81** to change the writing power intensity.

[**0043**] After test data recording to the reserved test area in the post-gap is finished, the microcomputer **60** determines an optimal writing power through the checking the jitter magnitude of test signals reproduced from the reserved test area (**S13**), and adjusts the output power of the optical driver **81** to the determined optimal writing power (**S14**).

[**0044**] After the optimal writing power has been set, the microcomputer **60** secures a pre-gap area first, then records the inputted user data behind the secured pre-gap using the optimal writing power (**S15**). When the recording of the user data is completed (**S16**), the microcomputer **60** reserves a post-gap area following the final recording location.

[**0045**] When testing for detecting an optimal writing power is accomplished in the reserved areas located before and/or behind data sections as explained above, it is preferable to write an additional information indicating that the reserved area is used for OPC in a TOC area to announce to other disk recording/reproducing devices not to misuse data recorded in this reserved area.

[**0046**] If inputted user data are recorded in the optical disk **10** and grouped in a session unit, the microcomputer **60** reserves a blank area behind a just-recorded session as shown **FIG. 6**. Then, before recording of new user data for a next session is started, the microcomputer **60** performs the above-explained optimal writing power detection in the reserved blank area following the recorded session.

[**0047**] The method and apparatus for detecting an optimal writing power according to the present invention reduces a delay time, which is required to move an optical pickup inwardly and outwardly to accomplish the OPC operation, from a recording request to practical data recording. The invention also enhances writing characteristics, since an optimal writing power is obtained from a test area which is very close to the area on which input user data are recorded.

[**0048**] Although the preferred embodiment of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as recited in the accompanying claims.

What is claimed is:

1. A storage medium, comprising:

a first area provided for recording test data and detecting an optimal writing parameter by test recording, the test recording being performed based on an indicative target writing power read from the storage medium; and

a second area provided for recording user data based on the detected optimal writing parameter,

wherein the first area is separated into a first part and a second part, the first part preceding the second area, and the second part following the second area, the test recording being performed on either the first part or the second part.

2. The storage medium according to claim 1, wherein the first area for the test recording has pre-sync data and post-sync data at a front end and a back end, respectively, to indicate the area for the test recording.

3. An apparatus for performing test recording on a storage medium, the storage medium including a first area provided for the test recording and a second area provided for recording user data, wherein the first area is separated into a first part and a second part, the first part preceding the second area, and the second part following the second area, the apparatus comprising:

a writer configured to selectively record test data to either the first part or the second part; and

a controller configured to determine an optimal writing parameter by test recording,

wherein the test recording is performed based on an indicative target writing power read from the storage medium.

4. The apparatus according to claim 3, further comprising:

servo control means for moving the writer to the second part for the test recording, the second part area for the test writing being reserved and being adjacent to the second area where the user data have been written most recently.

5. The apparatus according to claim 4, wherein the second part where the test recording is performed is located behind the second area where the user data have been recorded most recently.

6. The apparatus according to claim 3, further comprising:

servo control means for moving the writer to the second part for the test recording, the second part for the test recording being a blank area which is reserved and which is secured between data sessions.

7. A method for performing test recording on a storage medium including a first area provided for the test recording and a second area provided for recording user data, wherein the first area is separated into a first part and a second part, the first part preceding the second area, and the second part following the second area, the method comprising:

selectively recording test data to either the first part or the second part; and

determining an optimal writing parameter by the test recording,

wherein the test recording is performed based on an indicative target writing power read from the storage medium.

8. The method according to claim 7, further comprising the step of:

searching for a marginal area adjacent to the second area where the user data have been recorded most recently.

9. The method according to claim 8, wherein said searching step includes the step of searching for a marginal area located behind the second area where the user data have been recorded most recently.

10. The method according to claim 8, wherein said searching step includes the step of searching for a blank area secured between data sessions.

11. A method for performing test recording on a storage medium including a first area provided for the test recording and a second area provided for recording user data, wherein the first area is separated into a first part and a second part, the first part preceding the second area, and the second part following the second area, the method comprising:

identifying a data recording format; and

assigning either the first part or the second part for the test recording differently based on the identified recording format.

12. The method of claim 11, wherein the data recording format is a track-based or a session-based recording format.

13. The apparatus according to claim 3, wherein the first area for the test recording has pre-sync data and post-sync data at a front end and a back end, respectively, to indicate the area for the test recording.

14. The method according to claim 7, wherein the first area for the test recording has pre-sync data and post-sync data at a front end and a back end, respectively, to indicate the area for the test recording.

15. The method according to claim 11, further comprising the step of:

searching for a marginal area adjacent to the second area where the user data have been recorded most recently.

16. The method according to claim 15, wherein said searching step includes the step of searching for a marginal area located behind the second area where the user data have been recorded most recently.

* * * * *